Getting Started

Objectives

15.4.1 Describe some of the issues that relate to biotechnology.
15.4.2 Identify some of the pros and cons of genetically modified food.
15.4.3 Describe some of the ethical issues relating to biotechnology.

Student Resources

Study Workbooks A and B, 15.4 Worksheets
Spanish Study Workbook, 15.4 Worksheets

Build Background

Have students turn back to Figure 15–15 and examine the GM rice that contains increased amounts of provitamin A. Explain that this product was kept off the market for years in a dispute over who owned the patent for it and had the right to profits from its sale. Ask students whether they think it is ethical to keep healthful products off the market because of disputes over patents and profits. Then, ask whether they think it would be ethical to keep a cure for cancer off the market for the same reasons. Encourage diverse opinions.

THINK ABOUT IT

Years ago a science fiction movie titled Gattaca speculated about a future world in which genetics determines people’s ability to get ahead in life. In the movie, schooling, job prospects, and legal rights are rigidly determined by an analysis of the individual’s DNA on the day he or she is born. Are we moving closer to this kind of society?

Profits and Privacy

What privacy issues does biotechnology raise?

Private biotechnology and pharmaceutical companies do much of the research involving GM plants and animals. Their goal is largely to develop profitable new crops, drugs, tests, or other products. Like most inventors, they protect their discoveries and innovations with patents. A patent is a legal tool that gives an individual or company the exclusive right to profit from its innovations for a number of years.

Patenting Life

When you think about patents, you probably think about an inventor protecting a new machine or device. But molecules and DNA sequences can be patented, too. In fact, roughly one fifth of the known genes in the human genome are now patented commercially. Even laboratory techniques like PCR have been patented. When a scientist wants to run a PCR test, he or she must pay a fee for the license to use this process.

The ability to patent is meant to spur discovery and advancements in medicine and industry. After all, patent holders stand a good chance of reaping large financial rewards. Sometimes, though, patent holders demand high fees that block other scientists from exploring certain lines of research. That was the case in developing provitamin A-enriched golden rice, a GM plant described in Lesson 15.3. Even after the rice was developed, patent disputes kept it out of the hands of farmers for years.

Now consider the information held in your own genome. Do you have exclusive rights to your DNA? Should you, like patent holders, be able to keep your genetic information confidential? When it comes to your own DNA, how much privacy are you entitled to?

Teach for Understanding

ENDURING UNDERSTANDING DNA is the universal code for life; it enables an organism to transmit hereditary information and, along with the environment, determines an organism’s characteristics.

GUIDING QUESTION What are some of the ethical issues raised by genetic engineering?

EVIDENCE OF UNDERSTANDING After completing this lesson, assign students the following assessment to show their understanding of privacy issues related to genetic engineering. Ask students to draft a letter to a member of Congress or a state legislator about the use of information gathered from people’s DNA. Students should take a position on the issue and support it with logical reasoning and sound, scientific arguments. Have volunteers read their letters to the class. Ask other students whether they agree or disagree with the positions presented.
**Genetic Ownership** One of the most hallowed sites in the United States is the one shown in Figure 15–21. It is the Tomb of the Unknowns in Arlington National Cemetery, near Washington, D.C. Buried here are the remains of unidentified American soldiers who fought our nation’s wars. The tomb also serves as a focal point for the honor and remembrance of those service members lost in combat whose bodies have never been recovered.

Biotechnology offers hope that there will never be another unknown soldier. The U.S. military now requires all personnel to give a DNA sample when they begin their service. Those DNA samples are kept on file and used, if needed, to identify the remains of individuals who perish in the line of duty. In many ways, this practice is a comfort to military families, who can be assured that the remains of a loved one can be properly identified for burial.

But what if the government wants to use an individual’s DNA sample for another purpose, in a criminal investigation or a paternity suit? What if health-insurance providers manage their healthcare policies based on a genetic predisposition to disease? For example, suppose that, years after giving a DNA sample, an individual is barred from employment or rejected for health insurance because of a genetic defect detected in the sample. Would this be a fair and reasonable use of genetic information?

After considering this issue for years, United States Congress passed the Genetic Information Nondiscrimination Act, which became law in 2008. This act protects Americans against discrimination based on their genetic information. Physicians and ethicists hope this will lead to more effective use of personal genetic information, without fear of prejudice in obtaining health insurance or employment.

**Safety of Transgenics**

Are GM foods safe?

Much controversy exists concerning foods that have had their DNA altered through genetic engineering. The majority of GM crops today are grown in the United States, although farmers around the world have begun to follow suit. Are the foods from GM crops the same as those prepared from traditionally bred crops?

Pros of GM Foods The companies producing seeds for GM crops would say that GM plants are actually better and safer than other crops. Farmers choose them because they produce higher yields, reducing the amount of land and energy that must be devoted to agriculture and lowering the cost of food for everyone.

Insect-resistant GM plants need little, if any, insecticide to grow successfully, reducing the chance that chemical residues will enter the food supply and lessen damage to the environment. In addition, GM foods have been widely available for more than a decade. Careful studies of such foods have provided no scientific support for concerns about their safety, and it does seem that foods made from GM plants are safe to eat.

**Quick Facts**

**GM FOODS AROUND THE WORLD**

Here are a few quick facts about genetically modified foods grown around the world.

- In 2006, 252 million acres of GM crops were planted worldwide.
- The United States grew over half of the world’s GM crops in 2006, with 53 percent. Argentina was the next closest, with 17 percent.
- Most of the GM crops grown around the world in 2006 were herbicide-resistant or insect-resistant soybeans, corn, cotton, canola, and alfalfa.

**Less Proficient Readers** Before leading a discussion on the safety of transgenics, have students organize the information about the pros and cons of GM foods in a T-Chart. Tell students to use the blue headings in their text as the chart’s column heads, making the left column, Pros of GM Foods, and the right column, Cons of GM Foods. They should list opposing arguments in the two columns. Have students work with a partner to check their charts, and then use their charts during class discussion.

**Study Wkbks A/B, Appendix S30, T-Chart. Transparencies, GO15.**

**Lead a Discussion**

Have students review the information on transgenic safety on this page and the next. Then, discuss the issue as a class, using the open-ended questions below. Make sure students support their opinions with logic and reason.

**Ask** Which argument do you find more convincing, the argument for GM foods or the argument against?

**Ask** Would you be concerned if you found out that some of the food you eat regularly is genetically modified?

**Ask** Do you think farmers and food manufacturers should have to label their products if they are genetically modified?

**DIFFERENTIATED INSTRUCTION**

**LPR** Less Proficient Readers Before leading a discussion on the safety of transgenics, have students organize the information about the pros and cons of GM foods in a T-Chart. Tell students to use the blue headings in their text as the chart’s column heads, making the left column, Pros of GM Foods, and the right column, Cons of GM Foods. They should list opposing arguments in the two columns. Have students work with a partner to check their charts, and then use their charts during class discussion.

**Study Wkbks A/B, Appendix S30, T-Chart. Transparencies, GO15.**

**Lead a Discussion**

Have students analyze nutrition and genetic data to learn how genetically modified crops can help improve nutrition in Data Analysis: Genetic Engineering for Nutrition.

**Answers**

**FIGURE 15–21** Opinions may vary. Accept any opinion that is supported by logical reasoning.
Connect to the Real World

After students have read the section, Ethics of the New Biology, divide the class in half. Assign one half to take the position that strong government regulations are needed to control the development and use of biotechnology. Assign the other half to take the position that the field of biotechnology should remain free of regulation, which would only stifle new developments. Have groups meet, make a list of points that support their position, and choose two or three representatives to speak for the group. Then, have the representatives from each group debate the issue.

DIFFERENTIATED INSTRUCTION

**ELL Advanced Students** In anticipation of the debate described above, ask a few students in each group to search online for arguments for and against regulation of GM foods and other uses of genetic engineering. Give students a day or two of research time before holding the debate.

**ELL Focus on ELL:** Build Background

ALL SPEAKERS Have students fill in a Cluster Diagram for the topic of ethics. Have them brainstorm a list of words and phrases that relate to ethics, and write them on the board. For each word, call on advanced or advanced high speakers to pronounce the word correctly and use it in a sentence. Have beginning and intermediate speakers repeat the correct pronunciation. After discussion, have students choose the words from the list that they will include in their cluster diagram.


---

**Answers**

**IN YOUR NOTEBOOK** Pros: crops produce higher yields, lowering the cost of food; insect-resistant varieties require little pesticide, reducing the chance of chemical residues in the food supply and reducing pesticides in the environment; they seem to be safe to eat. Cons: no long-term studies have been made concerning potential hazards; there may be possible unintended consequences to agriculture; engineered insect resistance may threaten beneficial insects; use of herbicide-resistant plants may lead to increased herbicide use; higher cost of seeds may force small farmers out of business.

**Con of GM Foods** Critics acknowledge some benefits of genetically modified foods, but they also point out that no long-term studies have been made of the hazards these foods might present.

**Ethics of the New Biology**

**Should genetic modifications to humans and other organisms be closely regulated?**

“Know yourself.” The ancient Greeks carved this good advice in stone, and it has been guiding human behavior ever since. Biotechnology has given us the ability to know ourselves more and more. With this knowledge, however, comes responsibility.

You’ve seen how easy it is to move genes from one organism to another. For example, the GFP gene can be extracted from a jellyfish and spliced onto genes coding for important cellular proteins. This ability has led to significant new discoveries about how cells function.

The same GFP technology was used to create the fluorescent zebra fish shown in Figure 15–22. These fish—along with fluorescent mice, tadpoles, rabbits, and even cats—have all contributed to our understanding of cells and proteins. But the ability to alter life forms for any purpose, scientific or nonscientific, raises important questions. **Just because we have the technology to modify an organism’s characteristics, are we justified in doing so?**

---

**Quick Lab GUIDED INQUIRY**

**Survey Biotechnology Opinions**

1. Select three safety, legal, or ethical issues related to genetic engineering.
2. Design a survey to ask people their opinions on these issues.
3. Find 15 people to answer your survey.
4. Collect the surveys and tabulate the answers.

**Analyze and Conclude**

1. **Analyze Data** Did all respondents agree on any issue? If so, which one(s)?
2. **Draw Conclusions**
   - If you had surveyed more people, do you think you would have found more or less agreement in the responses? Why or why not?
3. **Evaluate**
   - How informed about biotechnology issues were the people you surveyed? If you were a politician or government official, how would you act on the results of your survey?

**ANALYZE AND CONCLUDE**

1. Answers will vary. Students should cite specific questions and provide evidence from the survey results.
2. Sample answer: Surveying more people may have yielded less agreement, because the sample might be more diverse.
3. Answers may vary, depending on survey results.

**Purposes**

Students will design and conduct a survey on genetic engineering and draw conclusions from the results.

**Planning**

Suggest students limit answers to responses such as Strongly Agree, Agree, Disagree, Strongly Disagree, Don’t Know. Recommend students survey people of varying ages and backgrounds.
It would indeed be marvelous if biotechnology enabled us to cure hemophilia, cystic fibrosis, or other genetic diseases. But if human cells can be manipulated to cure disease, should biologists try to engineer taller people or change their eye color, hair texture, sex, blood group, or appearance? What will happen to the human species when we gain the opportunity to design our bodies or those of our children? What will be the consequences if biologists develop the ability to clone human beings by making identical copies of their cells? These are questions with which society must come to grips.

The goal of biology is to gain a better understanding of the nature of life. As our knowledge increases, however, so does our ability to manipulate the genetics of living things, including ourselves. In a democratic nation, all citizens—not just scientists—are responsible for ensuring that the tools science has given us are used wisely. This means that you should be prepared to help develop a thoughtful and ethical consensus of what should and should not be done with the human genome. To do anything less would be to lose control of two of our most precious gifts: our intellect and our humanity.

It would indeed be marvelous if biotechnology enabled us to cure hemophilia, cystic fibrosis, or other genetic diseases. But if human cells can be manipulated to cure disease, should biologists try to engineer taller people or change their eye color, hair texture, sex, blood group, or appearance? What will happen to the human species when we gain the opportunity to design our bodies or those of our children? What will be the consequences if biologists develop the ability to clone human beings by making identical copies of their cells? These are questions with which society must come to grips.

The goal of biology is to gain a better understanding of the nature of life. As our knowledge increases, however, so does our ability to manipulate the genetics of living things, including ourselves. In a democratic nation, all citizens—not just scientists—are responsible for ensuring that the tools science has given us are used wisely. This means that you should be prepared to help develop a thoughtful and ethical consensus of what should and should not be done with the human genome. To do anything less would be to lose control of two of our most precious gifts: our intellect and our humanity.

Assess and Remediate

EVALUATE UNDERSTANDING

Ask students to write a paragraph describing the ethical issue from this lesson that they found to be the most important. Have them include an explanation of why they feel that particular issue needs to be resolved. Then, have students complete the 15.4 Assessment.

REMEDIATION SUGGESTION

Struggling Students If students have difficulty answering Question 1b, remind them that many illnesses with a genetic component show up in a person’s genes before the person gets ill. Suggest students consider a situation in which an insurance company knows of a person’s genetic predisposition to an illness before the person knows.

Students can check their understanding of lesson concepts with the Self-Test assessment. They can then take an online version of the Lesson Assessment.

Assessment Answers

1a. a legal tool that gives an individual or company the exclusive right to profit from its innovations for a number of years

1b. Sample answer: It could be used to analyze my DNA and bar me from employment or health insurance, based on genetic information.

2a. Genetically modified foods are foods that contain ingredients from organisms that have had their DNA altered.

2b. Answers may vary but should show an understanding of how plants are genetically modified with animal genes.

3a. Sample answer: whether genetic engineering will be used wisely and ethically

3b. Sample answer: How will genetically modified plants and animals affect other organisms in their ecosystem? If a company has a patent on a gene, can that company deny its therapeutic use to people who are too poor to pay? Are there any long-term health effects of eating GM foods?

4. Answers will vary. Some students might suggest that genetically altering a child’s inherited traits would be ethical to ensure the child doesn’t develop an inherited disease later in life, but would not be ethical simply to make the person more attractive or a better athlete.